The Relationship between Lyme Disease and Landscape Development Pattern

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THE DISEASE

Lyme disease is the most common vector-borne illness in the U.S., with 23,763 cases reported in 2002. States in the Northeast and upper Midwest report the most cases.

It is a potentially serious, though non-lethal, disease caused by the bacterium *Borrelia burgdorferi*. The bacterium is transmitted to humans and animals during feeding by hard-shelled ticks such as the black-legged tick (*Ixodes scapularis*). Research suggests that human cases are associated primarily with tick exposure around the home (peridomestic exposure).

Initial symptoms include: rash around the bite, fatigue, fever, and headache. If infection is untreated, the disease can cause severely debilitating musculoskeletal, cardiac, and neurological ailments.

The incidence of Lyme disease is increasing and may be exacerbated by global climate change. Widespread trends in low-density development raise the potential for increased human exposure to ticks and resulting infection in endemic areas.
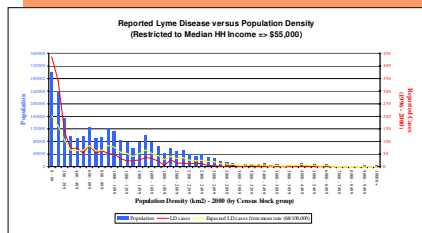
and its NATURAL HISTORY
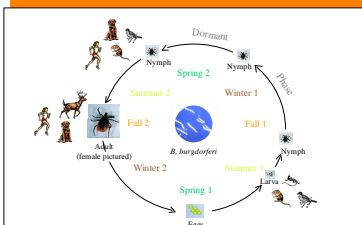
Two-Year Life-Cycle of Ixodes scapularis, with Hosts and Lyme Disease Agent

Lyme disease results in part from land-cover change that brings people into proximity with the tick vector and its native hosts.
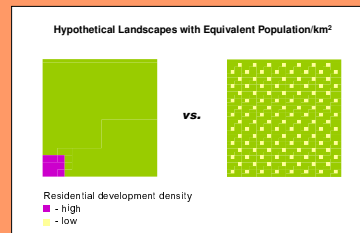
The principle host of *I. scapularis* in its larval and nymphal stages is the white-footed mouse; its preferred host as an adult is the white-tailed deer. Given a favorable environment, the distribution of deer determine the vector's presence in the landscape.

The role of the white-footed mouse is also critical to disease transmission. As the bacterial reservoir, this species maintains spring infection from second-year nymphs sufficiently long to transmit the pathogen to uninfected summer larvae.

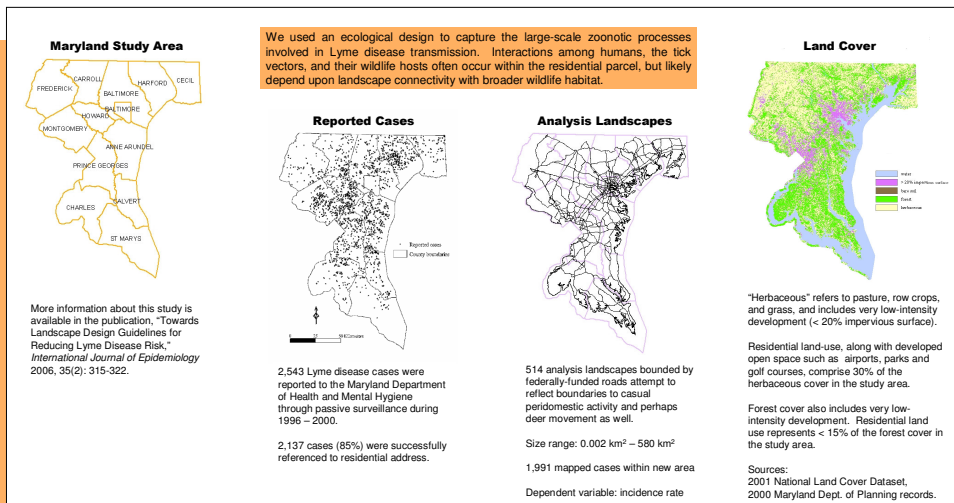## THE QUESTION: CAN WE QUANTIFY AN ASSOCIATION WITH DEVELOPMENT PATTERN?

Reported Lyme Disease versus Population Density
(Restricted to Median HH Income => $55,000)

POPULATION DENSITY SEEMS IMPORTANT IN DISEASE RATE . . .

Hypothetical Landscapes with Equivalent Population/km²

vs.

Residential development density
- high
- low

BUT HOUSING CONFIGURATION MUST ALSO MATTER

ECOLOGICAL APPROACH

Maryland Study Area

More information about this study is available in the publication, "Towards Landscape Design Guidelines for Reducing Lyme Disease Risk," *International Journal of Epidemiology* 2006, 35(2): 315-322.

We used an ecological design to capture the large-scale zoonotic processes involved in Lyme disease transmission. Interactions among humans, the tick vectors, and their wildlife hosts often occur within the residential parcel, but likely depend upon landscape connectivity with broader wildlife habitat.

Reported Cases

2,543 Lyme disease cases were reported to the Maryland Department of Health and Mental Hygiene through passive surveillance during 1996 – 2000.

2,137 cases (85%) were successfully referenced to residential address.

Analysis Landscapes

514 analysis landscapes bounded by federally-funded roads attempt to reflect boundaries to casual peridomestic activity and perhaps deer movement as well.

Size range: 0.002 km² – 580 km²

1,991 mapped cases within new area

Dependent variable: incidence rate

Land Cover

"Herbaceous" refers to pasture, row crops, and grass, and includes very low-intensity development (< 20% impervious surface).

Residential land-use, along with developed open space such as airports, parks and golf courses, comprise 30% of the herbaceous cover in the study area.

Forest cover also includes very low-intensity development. Residential land use represents < 15% of the forest cover in the study area.

Sources:
2001 National Land Cover Dataset,
2000 Maryland Dept. of Planning records.

RESEARCH FINDINGS:

INCIDENCE RATE IS SIGNIFICANTLY ASSOCIATED WITH LANDSCAPE PATTERN.
KEY VAR: PERCENT FOREST-HERBACEOUS EDGE

Explanatory variables	Rate ratio	95% confidence interval	Cumulative R^2
Percent forest-herbaceous edge[§]	1.34**	1.26, 1.43	0.75
Percent forest[§]	1.51**	1.28, 1.79	
(Percent forest)²	0.95 *	0.91, 0.98	0.82
Median annual household income[§§]	1.34**	1.18, 1.53	
(Median annual household income)²	0.96**	0.94, 0.98	0.85

* p < 0.005 (two-sided).
** p < 0.0001 (two-sided).
§ Units are tens of percent.
§§ Units are tens of thousands of dollars.
Spatial autocorrelation p = 0.31 (two-sided).

In the full model, the highest incidence rate of Lyme disease occurs at 53.5% forest cover and $80,000 median annual household income.

EVERY TEN-PERCENT INCREASE IN FOREST-HERB. EDGE CORRELATES WITH A 34-PERCENT INCREASE IN LYME DISEASE INCIDENCE RATE

Modeled Influence of Percent Forest–Herbaceous Edge and Percent Forest on Incidence Rate of Lyme Disease
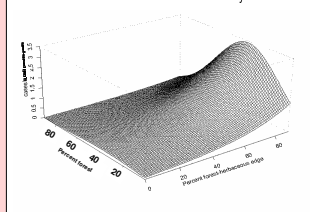
Incidence Rate is Highest in Landscapes with ~50% Forest / 50% Herbaceous Cover and a High Percentage of Edge Between These Cover Types

FINDINGS BEGIN TO QUANTIFY LAND-COVER PATTERN THAT RELATES TO HIGH LYME DISEASE INCIDENCE RATE IN MARYLAND

high forest-herbaceous edge, low forest/high herbaceous: **low Lyme disease**

low forest-herbaceous edge, 50% forest/50% herbaceous: **low Lyme disease**

high forest-herbaceous edge, 50% forest/50% herbaceous: **high Lyme disease**

RISK REDUCTION MAY BE MOST EFFECTIVE AT THE COMMUNITY LEVEL

Clustered Development and Moderate Residential Densities would minimize forest fragmentation and the resulting forest-herbaceous edge habitat that is strongly implicated in exposure

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